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# THE "MOTOR PRESENT" STATE IN MAN UNDER WATER IMMERSION CONDITIONS

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16. Abstract

The functional state of the segmental apparatus before voluntary movement was investigated in subjects under water immersion conditions. The H-reflex was used to evaluate the excitability of the spinal cord motoneurons. On the third, fourth, and fifth days of water immersion the increase in motoneuron pool excitability began 30 msec before EMG rather than the normal 60 msec. The absence of increase in excitability over the interval of 60-30 msec prior to movement is considered to be the consequence of disuse of the suprasegmental nervous structure involved in the spinal postural readjustment mechanisms.

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# THE "MOTOR PRESENT" STATE IN MAN UNDER WATER IMMERSION CONDITIONS

A. V. Ovsyannikov

To resolve questions of the influence exerted on the human organism by /305* certain factors of space flight under ground conditions wide use is made of an experimental model of hypodynamia with its various aspects such as strict confinement to bed, immersion of the subject in an immersion medium, and so forth [1]. Hypodynamia is known to be accompanied by lowering of the strength and tonus of the muscles [7, 8, 13], of static and dynamic endurance [6, 8], disruption of the stability of the body in the vertical posture and locomotion [5, 8, 13-15], and by change in the speed and accuracy of execution of motor acts [2, 6, 9]. The purpose of the present study was investigation of the functional state of the segmental apparatus of the spinal cord before the performance of voluntary movement by a person who had been in water for a lengthy period of time.

## Procedure

Seven adult males healthy to all intents and purposes took part in the experiments. The studies were conducted over a period of 10 days. For the first two days the subject followed an ordinary motor regime (background studies). For the following five days he was placed in a horizontal position on a net in a miniature tank of a volume of 4.4 $m^3$ containing an isotonic saline solution. The temperature of the solution was kept at the level of 34-34.6°. Over this period the subject was not allowed to stand up, sit down, and so forth (basic studies). After the period of presence in the aqueous environment the subject again maintained an ordinary motor regime (restoration period experiments).

The monosynaptic testing method (H-reflex) was employed in the experiments conducted for a period of 24 hours to evaluate the reflex excitability of the spinal motoneurons. In accordance with instructions the subject was to perform

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*Numbers in the margin indicate pagination in the foreign text.

plantar flexion when a visual signal was given. The signal directing movement was given at intervals of 10 seconds. At various times between the giving of the signal directing movement and appearance of the wavefront of the electromyogram of the agonist an H-reflex was induced in the gastrocnemius muscle. It was induced by electric stimulation of the nerve in the popliteal fossa by a rectangular pulse of a duration of 1 msec from the output transformer of the "Mul'tistim" electric stimulator. The reflex response was recorded by means of surface electrodes on the "Diza" myograph.

The control value of the H-reflex equal led 15-20% of the maximum amplitude /306 at rest. The stability of the response was determined in 10 consecutive tests before and after the experiment, and by the performance of 25-30 movements. In analysis of the H-reflexes induced during the latent period they were grouped on the basis of the time characteristic calculated from the electromyogram wavefront, after which the amplitude characteristics were determined.

The subject was recumbent during the experiment. In order to avoid the possibility of complications associated with use of electric current under water immersion conditions, the subject's right leg was placed on a special support situated a short distance above the water level. The angle in the knee joint was 90°, and 110-120° in the hip joint. This position of the subject was maintained in all the experiments.

## Results of Study

Background Studies. The motor reaction by the subjects was performed with a latent period of 170-220 msec. The latent period may be divided into three phases on the basis of the nature of change in the H-reflex of the gastrocnemius muscle. The first phase represents the time interval between giving of the visual signal up to 60 msec before movement, the second phase the interval between 60 and 30 msec, and the third the last 30 msec before movement. There is no appreciable change in the amplitude of the H-reflex during the first phase of the latent period. The value increases smoothly during the second phase and abruptly in the third (Figure 1, a, 2, a).

The term "motor present state" proposed by V. S. Gurfinkel' and Ya. M. Kots [4] will be used to designate the change in the reflex excitability of the spinal motoneurons determined by supraspinal defects during the last 60 msec before movement.

Study under water immersion conditions. In 24 hours the latent period of the motor reaction of the subjects increased to 50-80 msec under immersion conditions in comparison to that found in the background studies, and the subsequent four-day period of presence in the water brought about no appreciable new changes in it (Table 1).

TABLE 1. MOTOR REACTION LATENT PERIOD (msec) UNDER VARIOUS EXPERIMENTAL CONDITIONS (MEANS VALUE OF 10 CONSECUTIVE MOVEMENTS)

| Subject | Background | Under water immersion conditions after | | | | During restoration period After | | |
|---|---|---|---|---|---|---|---|---|
| | | 24 hrs | 48 hrs | 72 hrs | 96 hrs | 3-4 hrs | 24 hrs | 48 hrs |
| N. . . . | 190.5±4.6 | 267±6.6 | 268±6.9 | 274.5±6.1 | 269.5±6.0 | 274±7.14 | 233.3±6.8 | 203.9±7.6 |
| N. . . . | 208.5±5.16 | 291±9.1 | 288±9.9 | 281.5±8.1 | 289±9.6 | 253.5±10.3 | 232±7.4 | 205±6.6 |
| K. . . . | 170±9.6 | 231±12.04 | 235±8.1 | 235.5±11.4 | 230.2±7.5 | 210.5±10.7 | 209.5±7.1 | 190±6.01 |
| P. . . . | 221±15.4 | 294±20.1 | 275±19.1 | 275.5±17.8 | 280.5±17.7 | 274.5±17.2 | 240±16.6 | 220±16.2 |
| S. . . . | 185.5±9.8 | 245±8.7 | 243±11.4 | 246.5±15.3 | 250±12.4 | 220.5±7.7 | 224±8.4 | 190±7.8 |
| D. . . . | 200±6.2 | 254±7.7 | 248.5±6.5 | 259.5±4.9 | 250±7.4 | 235.5±5.5 | 226.1±7.6 | 198.7±6.4 |
| A. . . . | 183±10.3 | 251±14.3 | 253.2±17.5 | 251±16.5 | 249±16.3 | 223±14.1 | 225.5±9.8 | 205.2±11.7 |

Comparison of the H-reflex amplitudes on tracks 1, 2, 3, 4, 5 (Figure 1) shows that substantial changes take place in the nature of the motor present state under water immersion conditions.

The graphs in Figure 2 indicate the mean value of the H-reflex increment 60 msec before movement for the seven subjects. Only a slight decrease in the H-reflex increment in the second and third phases of the latent period is observed after 24 hours of water immersion. On the third day of presence of the subjects in the aqueous environment the increase in the H-reflex associated with impending movement occurs only during the third phase, the increment being entirely absent during the second phase, that is, 30 msec before movement rather than 60 msec, as was the case in the background studies. A motor present state of this nature was maintained on the fourth and fifth days of presence of the subjects under water immersion conditions (Figure 2, c, d). It is to be noted that increased fluctuation of the H-reflex during the motor present period in comparison to the initial data was observed on the same days. It is important to observe in this connection that there was virtually no change in /307 the H-reflex at rest (Table 2).

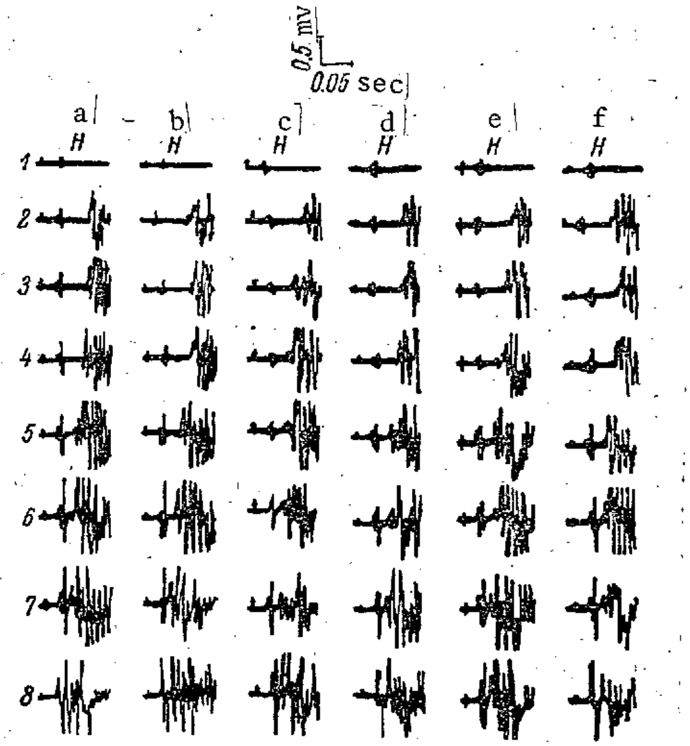


Figure 1. Nature of Change in H-Reflex of the Gastrocnemius Muscle in Subject S. Before Plantar Flexion Under Various Experimental Conditions.
a, Background studies; b, c, d, e, On second, third, fourth, and fifth days respectively of presence of subject in immersion medium; f, 3 hours after end of presence in immersion medium. 1, Control value of H-reflex at rest; 2, 3, 4, 5, 6, 7, H-reflex 60, 50, 40, 30, 20 and 10 msec before movement; 8, H-reflex coincides with electromyogram.

Restoration period studies. Restoration of the motor reaction latent period to the initial values occurred in four of the subjects on the third day after termination of the water immersion, and was not observed in three of the subjects. Three to four hours after termination of the water immersion the increase in the H-reflex amplitude in the second and third phases of the latent period were comparable to the amplitude increase value of the background studies (Figure 2, f). /308 However, the H-reflex variability continued to be high during these phases, decreasing somewhat on the second and third days (Table 2).

Discussion of Results

The data presented show that on the second day under water immersion conditions there is a substantial increase in the latent period of the motor reaction (Table 1), the motor present time remaining unchanged (Figure 2). It may thus be assumed that the increase in the latent period of the motor reaction under such conditions is due to "inhibition" in the suprasegmental structures forming movement. This apparently is due to change in the functional state of these structures.

This latter circumstance apparently represents the reason why the supraspinal structures form unstable commands and send them to the segmental level, as a result of which the variability of the H-reflex increases during the motor present period. The fact that the fluctuation in the H-reflex amplitude remains unchanged at rest serves to confirm this possibility.

TABLE 2. COEFFICIENTS OF VARIATION (CV) IN AMPLITUDE OF GASTROCNEMIUS MUSCLE H-REFLEX BEFORE MOVEMENT UNDER VARIOUS EXPERIMENTAL CONDITIONS (MEAN) VALUE FOR 7 SUBJECTS)

| Conditions and time of study | | At rest | Time (msec) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 60 | 50 | 40 | 30 | 20 | 10 | 0 |
| Background | | 15.3 | 18.4 | 20.4 | 18.63 | 18.4 | 19.6 | 19.53 | 15.4 |
| Water immersion | After 24 hrs | 14.0 | 26.6 | 29.6 | 28.2 | 29.4 | 28.7 | 28.1 | 16.2 |
| | After 48 hrs | 13.7 | 46.6 | 38.8 | 43.8 | 40.6 | 39.8 | 31.2 | 18.4 |
| | After 72 hrs | 16.0 | 50.3 | 53.7 | 54.7 | 48.4 | 37.82 | 34.3 | 18.6 |
| | After 96 hrs | 14.6 | 49.4 | 53.5 | 53.6 | 48.8 | 38.7 | 35.1 | 18.4 |
| Restoration Period After Immersion | After 3-4 hrs | 14.0 | 52.8 | 38.75 | 45.6 | 49.53 | 30.29 | 31.4 | 15.66 |
| | After 24 hrs | 15.3 | 32.8 | 35.9 | 34.6 | 39.7 | 27.3 | 21.1 | 15.5 |
| | After 48 hrs | 15.0 | 24.6 | 29.4 | 30.4 | 34.8 | 24.2 | 17.6 | 14.7 |

The data presented on the nature of variation in the reflex excitability of the motoneuron pool of the movement of the agonist obtained in the background studies are in agreement with the results of work by other authors [3, 4]. At the same time, it has been found in the present study that the motor present state is divided into two components, the first of which (from 60 to 30 msec /309
before movement begins) is absent in the third, fourth, and fifth phase of water immersion, while the latter (the last 30 msec before movement) is maintained. The absence of the first component of the motor present state may be due to changes in the muscular apparatus proper or to changes in the movement control center.

Special studies within the range of possible variation in the muscular tonus of our subjects have shown that the latent period, the duration of the H-reflex itself, and the EMG amplitude remain virtually unchanged in the case of spontaneous movement (author's unpublished data). There is thus reason for believing that a motor present state of this nature is due to change in the movement control system.

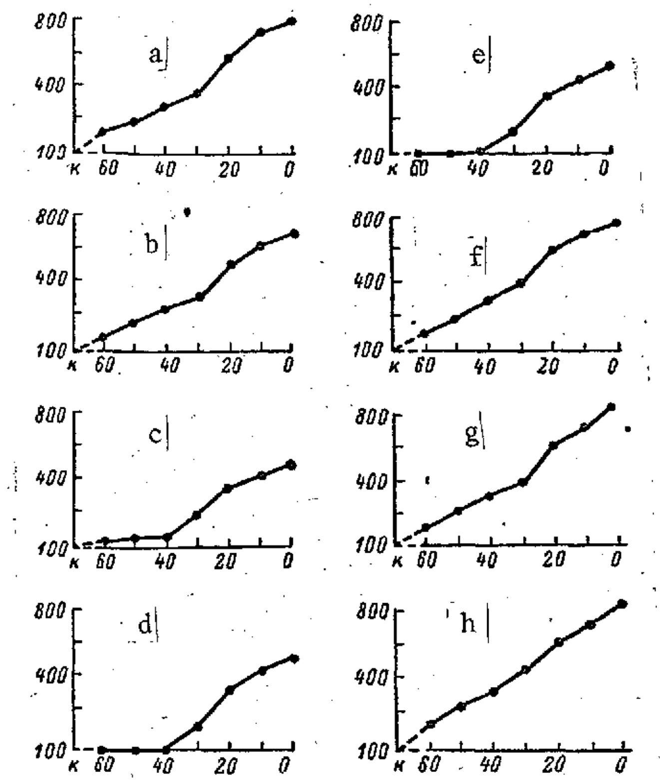


Figure 2. Increase in Amplitude of Gastrocnemius Muscle H-Reflex Before Movement Under Various Experimental Conditions. X-axis: time, in msec, before beginning of movement; Y-axis: H-reflex increase value, %: a, Background studies; b, c, d, e, Second, third, fourth, and fifth days respectively of presence of subject in immersion medium; f, g, h, 3, 24, and 48 hours respectively after termination of presence in immersion medium. Each point denotes the value of 70 tests (7 subjects times 10 tests).

There are at the present time a number of facts indicating that the processes taking place at the segmental level in the first and second components of the motor present state are functionally ambiguous. They include in particular the data on blockage of the various inhibitory and facilitatory effects during the last 20-30 msec before movement [3, 10, 11].

In analysis of the motor present state in a selection situation we advanced the hypothesis [12] that the supraspinal effect determining its first component "triggers" the spinal mechanisms of postural readjustment, while the effect determining the second component is associated with local movement. The data on the nature of the motor present state in a person under water immersion conditions represent an additional argument in favor of the hypothesis advanced earlier, inasmuch as the necessity of activation of postural readjustment mechanisms is eliminated under these ecological conditions. Hence the absence of the first component of the motor present state apparently is the consequence of "disuse" of the supraspinal nerve formation responsible for engaging the postural readjustment mechanisms.

Disruption of the postural regulation is also indicated by other data of ours obtained in study of the stability of maintenance of the body in a vertical posture and the vestibulomotor reaction and dynamics of change in the H-reflex in the galvanic vestibular test in persons taking part in such experiments.

Findings

1. In subjects immersed in water increase in the reflector excitability of the motoneuron pool of the agonist occurs 30 msec before movement on the third, fourth, and fifth days rather than 60 msec before movement as is the case under ordinary experimental conditions.

2. The absence of increase in the reflector excitability of the spinal motoneurons within the time interval from 60 to 30 msec before movement in persons immersed in water may be considered to be a consequence of "disuse" of the supraspinal nerve formations responsible for engagement of the spinal postural readjustment mechanisms.

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